



INSTRUCTIONS

COOLING WATER MAINTENANCE FOR DIESEL ENGINES

GENERAL

A cooling system will remain in excellent condition for the life of an engine if proper control is exercised over water conditioning and water treatment. Too often, however, inadequate attention is given to the preparation and control of cooling water. The consequences of a lack of cooling water maintenance are just as severe as those of insufficient maintenance of any other engine system.

Raw water contains impurities in varying amounts. These include dissolved minerals, dissolved gases and suspended solids. Even water which is entirely suitable for human consumption must be considered contaminated and requires conditioning before being used in a diesel engine cooling system.

The minerals in raw water will form hard scale deposits on heat transfer surfaces. Some minerals will form sludge at high water temperatures. Sludge and sediments often settle in water passages where the water flow velocity is low. The deposits act as an insulator and heat transfer is reduced. Additionally, corrosion occurs much more rapidly beneath such deposits. Figs. 1 and 2 show the consequences of inadequate cooling system maintenance.

CONDITIONING THE WATER

Before using raw water it should be analyzed for impurities. Table I lists the maximum concentration of impurities which would permit using the water without being cleaned up.

If analysis indicates that the raw water meets these limits, then add water treatment inhibitors directly to the

raw water to protect against corrosion. If the raw water contains impurities in excess of the concentrations listed in Table I, then it must first be processed by distillation, demineralization or de-ionization before adding the inhibitor.

CAUTION: *Distilled, demineralized or de-ionized water is corrosive and must not be used in a cooling system without further treatment, since it is mildly acidic.*

TABLE I, ACCEPTABLE COOLING WATER
(UNTREATED)

	Maximum	
	Parts Per Million (ppm)	Grains/Gal.
Chlorides	40	2.5
Sulfates	100	5.8
Total Dissolved Solids	340	20
Total Hardness	170	10
Suspended Solids	17	1

CHOOSING A CORROSION INHIBITOR

Numerous commercially available water treatment compounds may be added to the water to inhibit corrosion. While it is important that these additives be effective against corrosion they must also not be harmful to various synthetic materials found in the cooling system. An inhibitor which is successful in another application is not necessarily suited for a particular diesel engine cooling system. Differences in coolant velocity, temperature and types of materials make such comparisons meaningless.

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Verify numbers for parts, tools, or material by using the Renewal Parts or Tool Catalogs, or contact your General Electric representative for assistance. Do not order from this publication.

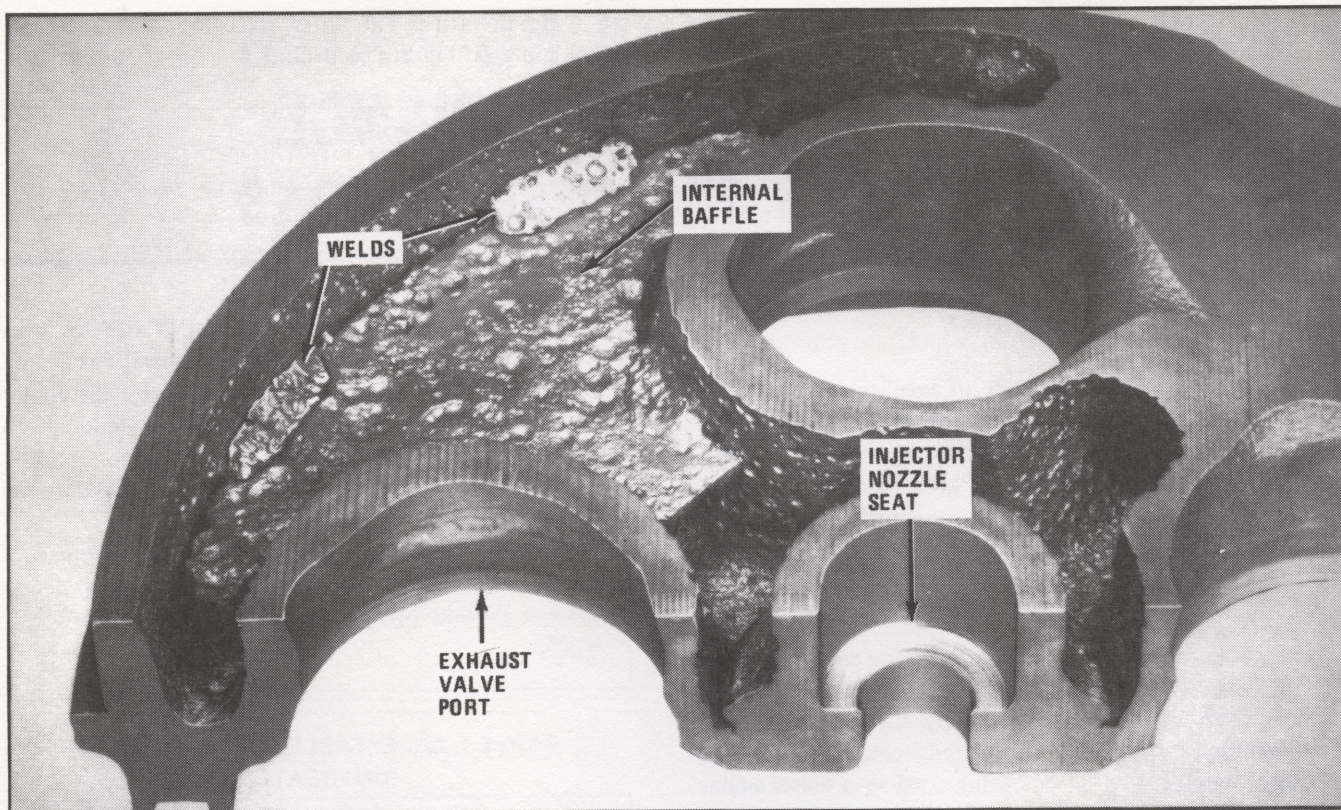


FIG. 1, E-26551

FIG. 1. SECTIONED CYLINDER HEAD SHOWING EXTREME INTERNAL CORROSION DUE TO INADEQUATE WATER TREATMENT.

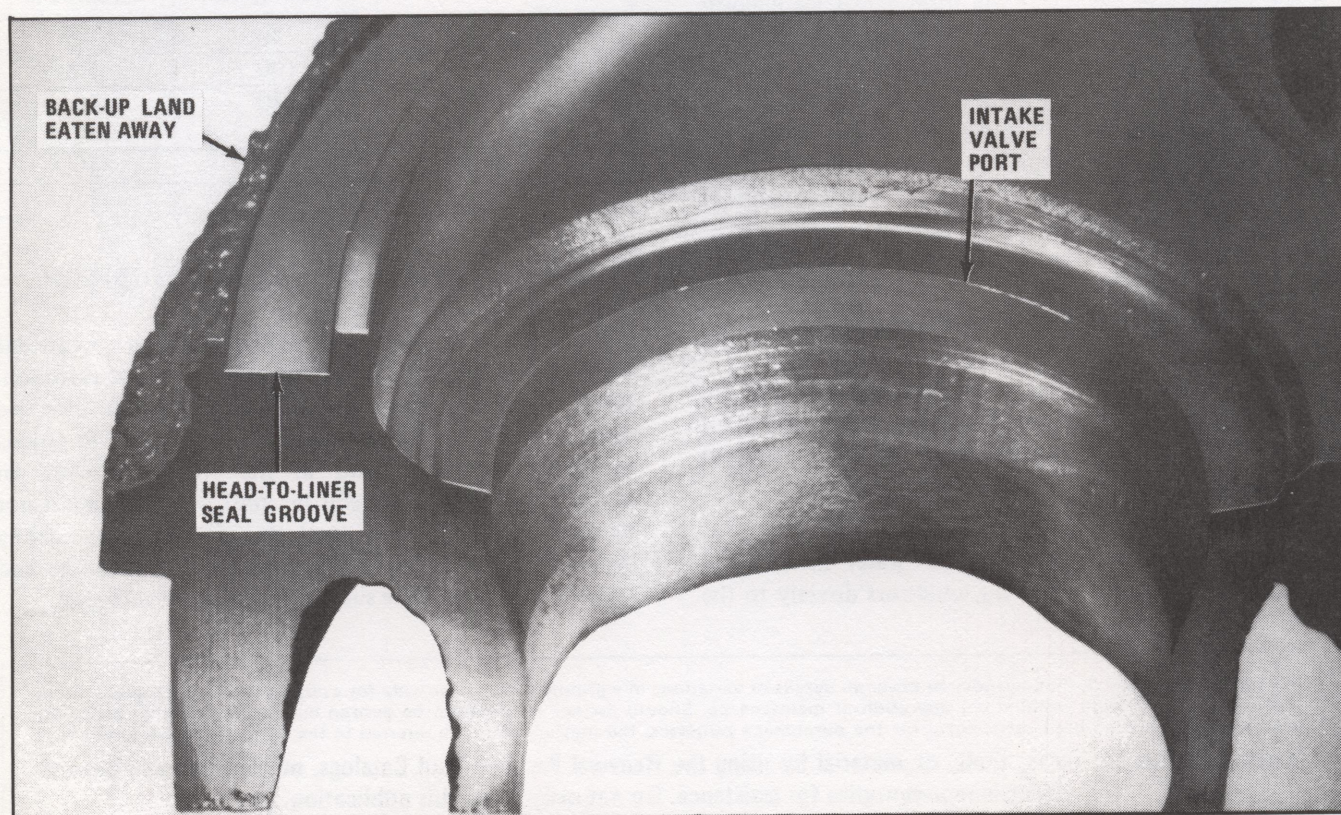


FIG. 2, E-26552

FIG. 2. CYLINDER HEAD — OUTER LAND WHICH BACKS UP SILICONE SEAL IS EATEN AWAY.

The first concern in protecting against corrosion is the maintenance of the proper level of alkalinity in the coolant. Alkalinity and acidity are expressed as numbers on the pH scale, which runs from 0 to 14. Numbers above 7 indicate an alkaline solution and the higher the number the stronger the alkaline solution. Numbers below 7 indicate an acid solution and the lower the number the stronger the acid solution. A pH value of 7 is neutral, being neither acid nor alkaline. Generally, coolant which is on the acid side will corrode ferrous materials such as cylinder jackets, liners, heads and water tanks. Coolant which is highly alkaline will corrode non-ferrous materials such as those found in radiators, intercoolers, the lube-oil cooler and the fuel oil heater.

Note in Fig. 3 that the recommended pH range differs depending on which type of inhibitor is used. Chromate inhibitors produce a pH range of 7.5 to 9.5, while borate-nitrite inhibitors produce a pH range of 10 to 11. Borate-nitrite inhibitors, however, are formulated so as to give additional protection to non-ferrous materials. Relatively high pH values are normal when using borate-nitrite.

The second concern in corrosion protection is the choice of inhibitor type, the principal types being chromate and borate-nitrite. Chromate is considered a better inhibitor so far as the equipment is concerned but is a potentially serious skin irritant, while various state and federal regulations restrict its disposal without special treatment. Where waste treatment is a problem, a borate-nitrite inhibitor may be

used. Borate-nitrite inhibitors are effective but are, in general, more difficult to control.

CAUTION: Do not mix chromate with borate-nitrite inhibitor. Do not mix different brands of the same type of inhibitor. The formulations may vary and inhibitor characteristics may be adversely affected if mixed. Follow the inhibitor manufacturer's recommendations.

MAINTAINING THE COOLANT

WARNING: All water treatment compounds are toxic to some degree and suitable care must be taken by persons handling them to avoid inhaling the fumes or dust and to avoid both skin contact and eye contact with either solids or solution.

CAUTION: Any dry form of treatment compound must be completely dissolved before it is added to the cooling system. Solutions should be prepared in open containers, with adequate ventilation. Parts and decks should be washed clean of dried-on or spilled compound.

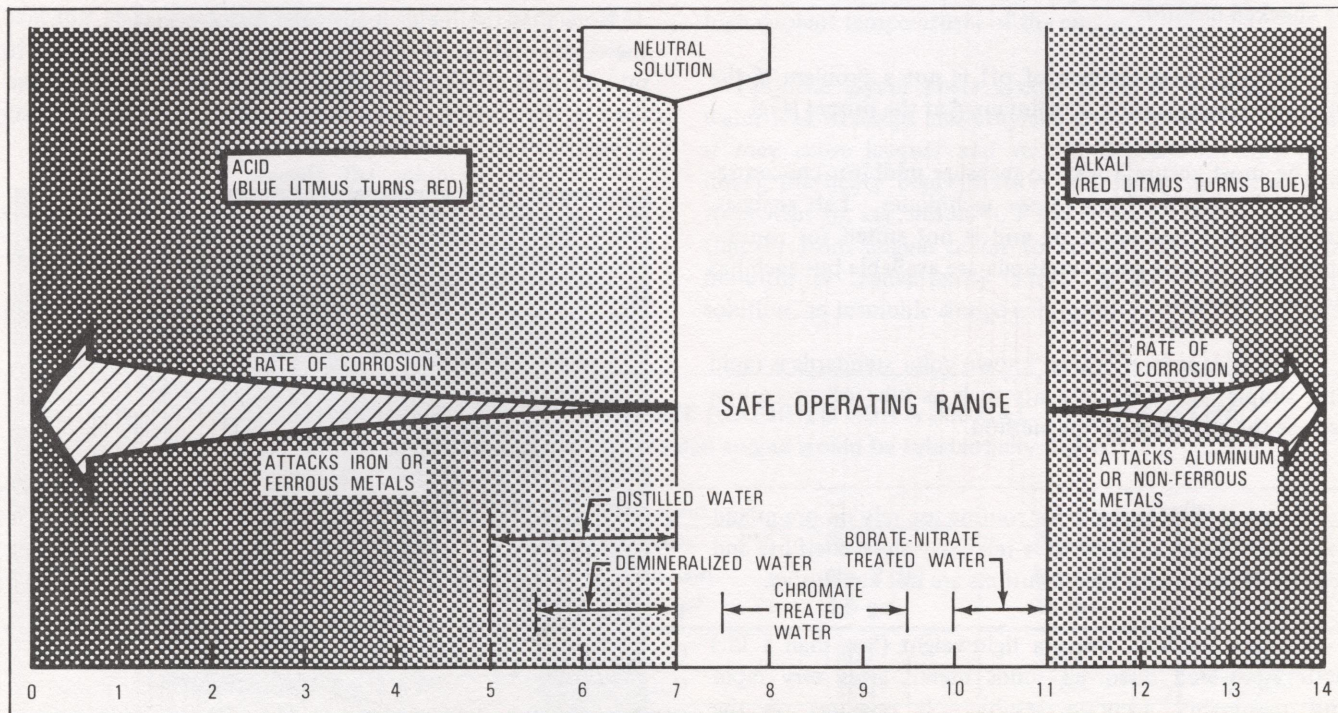


FIG. 3. CHART SHOWING PH FACTORS FOR COOLING WATER.

CHROMATE

The initial concentration of chromate in a new cooling system should be about 4000 ppm (parts per million as sodium chromate). Check the concentration at least weekly, as described under CHECKING THE COOLANT section, and add inhibitor as necessary to maintain a minimum concentration of 2500 ppm. After the system has stabilized, check it monthly and maintain the 2500 ppm minimum concentration.

BORATE-NITRITE

The recommended normal concentrations for most formulations are 1800 ppm borate and 1200 ppm nitrite. With a new cooling system it is necessary to double or triple this dosage until the system stabilizes. Make-up dosages should err on the rich side to compensate for normal depletion. Note, however, that extremely high concentrations of borate-nitrite inhibitor (five to ten times the recommended concentration) can cause loss of bond between the radiator silicone rubber tube sheet and the brass ferrules around each tube in that type of cooling system. The best course of action is to adhere to the recommended inhibitor concentrations.

CHECKING THE COOLANT

Coolant should be checked weekly in a new engine until its condition reaches a steady state. Thereafter it should be checked monthly.

Generally, maintenance of pH is not a problem if the inhibitor concentration is maintained at the proper level.

The most accurate way to measure inhibitor concentration is by standard laboratory techniques. Lab analysis, however, is time-consuming and is not suited for routine checking. Several other methods are available but each has its disadvantages.

Color comparison against known color standards is rapid and simple, but contaminants such as lube oil or carbon reduce the accuracy of this method.

Chemical tests suitable for routine use rely on pre-mixed materials. Some of these have relatively short shelf life and results obtained with aged solutions are not conclusive.

Another method, using a lightweight (less than 1 lb.) battery-powered dissolved solids meter, gives very rapid and reasonably accurate results. It operates on the principle that the electrical conductivity of a liquid solution

increases as the concentration of dissolved salts increases. Specific concentration can thus be easily measured.

The dissolved solids meter, with a range of 0 to 10,000 ppm, is available from General Electric as Tool No. 147X2261. It is used as follows:

1. Allow the sample being tested to cool to below 160 F.
2. Push the red button, Fig. 4, to check the internal standard calibration.

The calibration value is marked on the bottom of the meter. The calibration adjustment is under the snap-in disk on the bottom. Adjust it until the meter reading agrees with the calibration setting marked on the bottom of the meter.

NOTE: Replace battery if meter reading is less than full scale at maximum setting of calibration control.

3. Rinse cell cup three times with sample to be tested, then fill with sample.
4. Push black button, Fig. 5, to read parts per million.

Periodically, the meter should be calibrated using the standard 3000 ppm solution, Part 147X2262, provided with the meter.

Note that the meter reads total dissolved solids, not just the concentration of inhibitor. Other salts and minerals, if present, will affect the reading. This means that the water used in the cooling system must have been pre-conditioned as described above before the inhibitor was added.

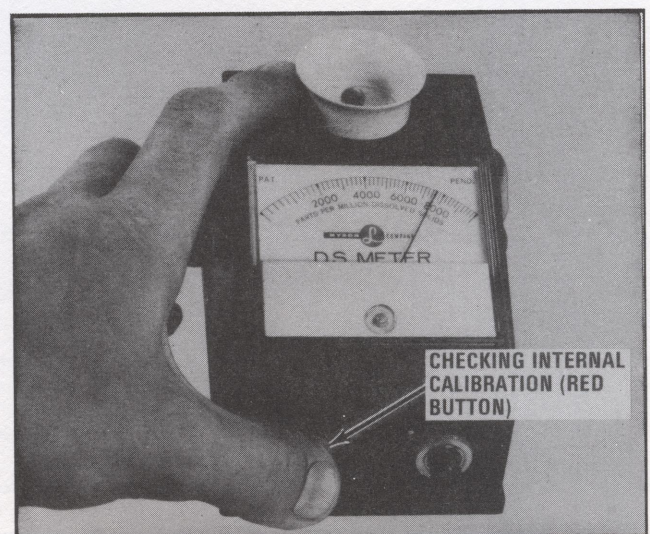


FIG. 4. CHECKING INTERNAL CALIBRATION OF METER.

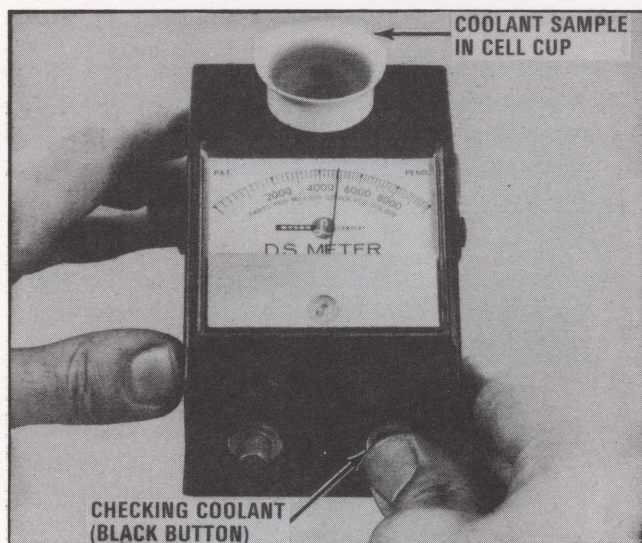


FIG. 5, E-26416

FIG. 5. CHECKING CONCENTRATION OF WATER TREATMENT.

Different brands of commercial inhibitors vary in the proportions of borate and nitrite. Therefore, a reference must first be established by laboratory analysis or by consulting with the inhibitor manufacturer to determine the meter reading at which one of the inhibitor constituents has reached a low value. This reading can then be used as a "go-no go" limit on subsequent checks.

Using the figures for Dearborn No. 537 and Nalco No. 39L as an example from Table II, it is apparent that the total dissolved solids reading for Dearborn No. 537 would be 4250 ppm if concentration is normal (by adding 1800 ppm borate and 2450 ppm nitrite). The reading for Nalco No. 39L, however, is only 3000 ppm (1800 ppm borate plus 1200 ppm nitrite).

Again, ALWAYS consult the inhibitor supplier for detailed recommendations and testing methods.

Make-up dosages should err on the rich side to compensate for normal depletion. For example, if the coolant

level is down 45 gallons ($45/300=15$ percent), and the system is using Nalco No. 39L, filling with this much coolant would require 15 percent of 4.5 gallons (4.5 gallons being the amount of treatment compound used for a full system charge), or about 2/3 gallon of Nalco No. 39L. Round it out to a full gallon.

On the other hand, if the system is full but either the borate or the nitrite has reached a low concentration, pre-dissolved inhibitor alone must be added to re-establish normal concentration. For example, to strengthen a full system from half the normal concentration to normal concentration requires one-half of a full dose of treatment. In the case of Dearborn No. 528, a full dose is 14 lbs. of powder (at 3/4 oz. per gal.). One-half of 14 lbs. is 7 lbs; add 7 lbs. to the tank, pre-dissolved in water.

NOTE: Brands of water treatment are mentioned only because of their broad use in diesel engine applications and are used only for example. Other brands of water treatment, of equal quality, may also be used.

ANTIFREEZE

General Electric does not recommend the use of antifreeze in the cooling system. Experience with antifreeze is limited. Additional evaluation would be required to assure long-term satisfactory operation.

Alcohol as an antifreeze is simply inadequate due to the high coolant temperatures of the engine.

Ethylene glycol poses several potential problems: if a water leak develops and ethylene glycol enters the lube oil it may cause lacquer and varnish deposits on rings and liners; the heavy concentration of ethylene glycol needed to protect to, say, minus 40 F has an adverse effect on heat transfer from engine metal to coolant; also, if chromate inhibitor is inadvertently added to an ethylene glycol solution, an insoluble sludge will form.

TABLE II, EXAMPLE OF FULL NORMAL DOSAGE REQUIRED FOR A 300 GAL. WATER SYSTEM.

Initial dosage on a new or newly overhauled engine would be substantially higher.

Resultant Concentration In 300 Gal.	Liquid			Powder	
	Dearborn No. 537 5.1 gal.	Nalco No. 39L 4.5 gal.	Nalco No. 2100 4.5 gal.	Dearborn No. 528 14 lbs.	Nalco No. 40 15 lbs.
Borate, ppm	1800	1800	1800	3900	3420
Nitrite, ppm	2450	1200	1200	1200	1200
Minimum Meter Reading	4250	3000	3000	5100	4620

If, however, it is determined that the consequences of freezing are greater than those resulting from the potential problems inherent in using ethylene glycol, the following guidelines should be observed:

1. Use pure monoethylene glycol and preconditioned water. The suggested concentration of antifreeze is between 33 percent and 68 percent by volume. A 50 percent solution protects to minus 40 F. A 68 percent solution protects to about minus 62 F. Using an antifreeze concentration above 68 percent

will actually raise the freezing point and will not provide satisfactory heat transfer.

2. Add borate-nitrite treatment as described above. Do not mix with an automotive type antifreeze. The inhibitors in it may be incompatible. Under no circumstances should a chromate-type inhibitor be used.
3. Do not use any antifreeze containing so-called anti-leak compounds. They may cause plugging in the system, especially in small passageways.

NOTES: